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R E M A R K S

The Office Action issued June 23, 2008 has been received and its contents have been carefully considered.

Claims 1-7 stand rejected under 35 USC §103(a) as being unpatentable over U.S. Patent No. 5,633,495 to Niehuis, in view of U.S. Patent No. 4,426,582 to Orloff, and in further view of Van De Walle et al., "Study of Bi_n^{P+} Ions Formed in Liquid-Metal Ion Sources", Phys. Rev. 1987. This rejection is respectfully traversed for the reasons given below.

Claim 1 is a Jepson style claim, with the improvement recited to be relating to the liquid metal layer of the heatable ion emitter. The liquid metal layer is recited to be essentially pure Bismuth or of a low-melting-point alloy containing, in essence, Bismuth. A Bismuth ion mixed beam can be emitted by the ion emitter under the influence of an electric field. A filtering device filters out one of a number of Bismuth ion types. The types have mass, which is a multiple of monatomic or multiply charged Bismuth ions

Bi_1^{p+} The type filtered out is Bi_n^{p+} , where $n \geq 2$ and $p \geq 1$, with n and p being integers. This notation is defined in the specification, e.g. at p. 1, second paragraph. In this definition, the specification explains that the notation refers to Bismuth clusters where n is the number of ions in a cluster.

Thus, in claim 1, the source is Bismuth and the cluster size is greater than or equal to 2.

The other independent claim is analogous, but only recites the source rather than the whole mass spectrometer.

In discussing the claim recitations, the Examiner mischaracterizes them by stating that the claims say Bi_1^{p+} rather than Bi_n^{p+} . Applicants would like to note for the record that the claim is not limited the way the Examiner states. Applicants have specifically recited that $n \geq 2$.

Non-Obvious To Use Cluster Sizes ≥ 2 ?

The Niehaus reference is concerned with a TOF-SIMS (time of flight secondary ion mass spectrometer) using a static beam of primary ions deriving from a source of ions (col. 2, l. 39-40). This static beam is pulsed to get a pri-

mary-ion pulse with a duration of only a few nanoseconds (col. 2, 1. 36-38).

It is the declared aim of this reference to provide a TOFSIMS that will employ shorter measurement times without loss of mass resolution (col. 3, 1. 1-2).

In detail, Niehuis teaches a time-of-flight mass spectrometer for the analysis of secondary ions and post-ionized neutral secondary particles. This instrument includes a continuous source (ref. IQ, all references with respect to fig. 1) of pulsed primary ions, pulsed by an appropriate beam pulser PS, resulting in the aforesaid primary ion pulse. (column 4, lines 12-15). The pulsed beam is filtered through a mass filter MF and focused on and positioned over a sample P (target) with focusing mechanism FK and a grid mechanism RS (column 4, lines 18-21).

Niehuis also states at col. 2, line 36 et seq.

The primary-ion pulse duration necessary for high mass resolution is only a few nanoseconds for a typical drift of approximately 2 m. The pulses are generated by an appropriate beam-pulsing procedure from a static beam deriving from a source of ions. The number N_p of primary ions per pulse derives from the static current I_p through the ion source and pulse duration t_p in the form

$$N_p = I_p * t_p / e$$

wherein e is the elementary charge.

It will accordingly be evident that the number of primary ions per pulse will decrease with the length of the pulse. Consequently, more primary-ion pulses will be necessary to generate and detect the same number of secondary ions. This means that the measurement time will increase. The increased measurement time is a particular problem in the analyses of microscopically dimensioned areas with finely focused ion sources because the available ion-source currents I_p are very small. The recording of spectra of higher dynamics, of lateral distributions, and of distributions in depth often result in measurement times of more than one hour to several hours.

Although Niehuis does not teach the type of ion source to be used, one of ordinary skill reading Niehuis would conclude that the measurement time at constant pulse duration t_p is directly dependent on the static current I_p . The skilled artisan would therefore attempt to maximize this primary static ion current for any given type of primary ion source.

Niehuis further teaches to use a mass filtering device MF to form a mass-pure ion beam. Therefore, for any mixed primary ion beam, the skilled artisan would select the most intense component in order to keep the analysis time short. All other species with lower intensities would be filtered out by the mass filtering device.

But, the van de Walle reference teaches that Bi_1^+ is the most intense, per Fig. 1. This may not be immediately apparent from the figure, but the Examiner should note that the figure has a logarithmic scale - though the readings are difficult to decipher given that no units are given on the vertical scale. Therefore, one of ordinary skill in the art, if he happened to look at van de Walle and despite the vagueness of figure, would not think that the clusters with $n \geq 2$ would be desirable. They would think that Bi_1^+ would be desirable.

Hence the combination fails to teach or suggest the cluster size recited in the independent claims

Obvious To Use Bismuth As An Ion Source?

The Examiner cites Niehuis with respect to the preamble portion of the claim - i.e. the portion recited before the improvement. The Examiner recognizes that Niehuis fails to teach or suggest Bismuth.

For this improvement, the Examiner cites Orloff and Van der Walle.

Orloff

Orloff discloses the use of ion guns with a highly focused ion beam of high current (very small spot area) (col. 2, l. 46-50, col. 1, l. 64).

In detail, Orloff teaches a liquid metal ion source including the liquid metal ion source design, source operating conditions and special ion optics for the focusing of the ion beam. He teaches that in situations typical of lithography or surface analysis, high currents are desired in focused beam spots of approximately 1,000 - 2,000 Angstroms (column 1, lines 63-66). Orloff provides a method of focusing an ion gun. The reference states as an object having a liquid metal field ionization source to provide reliable, uniform beam currents and to minimize energy spread of the ion beam produced by the ion gun (column 2, lines 28-32).

The data presented by Orloff relates to Gallium. Per Fig. 2A, for Gallium liquid metal ion guns the energy spread could be as low as 5.3 eV and possibly as high as 25eV. If one were to try to optimize the source, by losing less ions, and one used lower current, this data shows that for the *optimized* Gallium liquid metal ion source the energy spread at low emission currents would be about 5.3 eV.

A person of ordinary skill reading Orloff would infer that - for an intense and well focused beam that optimizes a liquid metal ion source - energy spread is an important contributing factor. Orloff implies that Gallium's energy spread is already "large" and therefore challenging to focus, per col. 2. 11. 20-23. Accordingly, the reader would infer that materials having an even larger spread would be problematic.

The Orloff reference shows detailed data only with respect to a Gallium liquid metal ion gun based on a tungsten emitter. In a quite speculative manner without providing details or experimental data he states that "Similar experiments have also been performed with liquid Indium and liquid Bismuth, with results entirely analogous to those described above" (column 10, lines 14-17).

As Orloff states that Bismuth shows analogous (even if not same) results as Gallium, a person of ordinary skill in the art would assume from Orloff that Bismuth must have a similar energy spread as Gallium in order to work with the focusing mechanism disclosed.

In fact since this reference was published in 1984, Gallium liquid ion sources became a great success in mass

spectroscopy, while no one ever put Bismuth liquid ion sources into practice, and van de Walle explains, in part, why this was.

Van de Walle

Applicants respectfully submit that the Examiner completely mischaracterizes this reference.

This reference is not related to how to build or operate SIMS machines. Van de Walle mentions SIMS, but only with respect to results obtained with SIMS, for instance:

"There appears in the mass spectrum of these elements a regular odd-even alternation depending on the p charge state X=Cu, Ag, Au ... This phenomenon which also appears in secondary-ion mass spectroscopy (SIMS)¹¹ is due to the fact that aggregates with an even total number of valence electrons have larger stabilities." P. 5509

In other words, secondary ion mass spectra of Ag, Cu, and Au (as secondary ions) have been generated by the bombardment of solid metal foil with xenon ions as primary ion beam front - a discharge type ion gun using a magnetic sector type secondary ion mass analyzer. Reference 11 by Katakuse et al. is cited to show that similar regular odd-even alternations are reported with SIMS. Therefore the statements about SIMS are about the results to be obtained with SIMS, not about the structure or operation of SIMS

machines. Moreover, the complete energy distribution is from the Xenon source, not Bismuth.

Similarly, on p. 5511 of Orloff, SIMS is mentioned in passing as giving similar results, but again nothing is stated about how to structure or operate SIMS machines.

Applicants accordingly respectfully submit that the statement of the Examiner that "Van de Walle teaches the use of a liquid metal ion source and SIMS to obtain a complete energy distribution Bi_n^{p+} spectra" is incorrect and misses the point. Van de Walle uses Xenon to measure these complete spectra; moreover, the present application does not relate to making measurements of Bismuth ions, but rather to using Bismuth ions to make measurements.

In fact, as explained further below, van de Walle teaches away from such using Bismuth, when combined with Orloff.

Looking at the merits of this reference, Van de Walle measures energy distributions of some Bismuth cluster ions (see figs. 2 to 4). However, the energy spread of all these Bismuth clusters is larger than the energy spread of Gallium as taught by the Orloff reference. For example in the best case of Bi_4^+ the energy spread is about 30 eV and in other

cases like Bi_6^+ it shows even a two-peak distribution with an energy difference of more than 100 eV (see page 5511, Fig. 2); however, as pointed out before, one of ordinary skill in the art would already be thinking that Bi_1^+ was the most desirable ion, because it was the most intense.

Therefore, one of ordinary skill in the art, reading both Orloff and van de Walle, and seeing that van de Walle was later than Orloff, would believe Orloff was mistaken that Bismuth would really work in Orloff's focusing mechanism. If they wanted to check out Bismuth, they would be compelled to perform extensive experimentation.

It is the achievement of the present inventors to overcome this teaching by Orloff and Van de Walle and to realize against their teachings the high sensitivity in secondary ion production achievable with an ion beam of a single species of Bi clusters.

Summary of the References

If one of ordinary skill would learn from Niehuis

- the importance of intense primary ion sources with high ion currents for time-of-flight secondary ion mass spectrometry in spectroscopy and imaging mode

- that all impurity species with lower intensities must be filtered out by a primary ion mass filter so that only the most intense ion species is used,
and would learn from Orloff
- that Bismuth liquid metal ion sources exist besides the Gallium liquid metal ion source then,
he would conclude
- from Van de Walle that the most intense species in the primary spectrum of Bi is Bi_1^+
- from Niehuis that the most intense species has to be selected for optimum intensities and analysis speed
- from Niehuis that all other species must be filtered out of the beam
- from Van de Walle that the energy spread of Bi ions is by far inferior to the energy spread of Orloff's Ga-ion source,
- from Orloff that the primary ion beam must have an energy spread as low as possible.

Hence, the teaching Of Niehuis and Orloff together with the results of Van de Walle would teach somebody with ordinary skill away from using Bismuth clusters. There is absolutely no indication that using Bismuth as liquid metal ion sources and using the less intense Bismuth clusters would have any advantage in any application of time-of-flight secondary ion mass spectrometry.

Effort to Achieve the Present Invention

Orloff hints at liquid Bismuth sources that consist of tungsten emitters wetted with liquid Bismuth. Although Orloff stated back in 1984 that results with Bismuth were allegedly analogous to those described for Gallium (column 10, lines 14-17), Bismuth liquid metal ion sources have never been applied in lithography and surface analysis since. In contrast, Gallium liquid metal ion sources as characterized by Orloff have been quite successfully commercialized. Work on Bismuth was limited to a very few scientific papers like Van de Walle.

There are two main reasons for this:

- Bismuth liquid metal ion sources never worked reliably and stably. Liquid Bismuth does not really

wet tungsten emitters well enough to be used in any of the applications mentioned by Orloff.

- Bismuth liquid metal ion sources have beam characteristics inferior to Gallium with respect to energy spread and angular intensities.

Hence, one of ordinary skill would normally have concluded that Bismuth liquid metal ion sources are inferior to Gallium and cannot be operated in a reliable and stable way as is mandatory in lithography and surface analysis.

For the inventors of the present invention it took about 1 man year of a very skilled Ph.D. scientist with a degree in physics and with 7 years of experience in liquid metal ion sources and 9 years experience in secondary ion mass spectrometry in collaboration with a skilled technician to achieve positive results with a Bismuth liquid metal ion source in SIMS.

For example it was found that a clean tungsten emitter as described by Orloff was not wetted at all by liquid Bismuth. No stable operation even for a rather short period could be achieved under these conditions. Finally, only after intense research and testing of various other emitter materials, an appropriate emitter material was identified

and could be wetted by Bismuth. This emitter finally was tested successfully. Such a working Bismuth emitter is, however, a prerequisite for making the present invention. In other words, the present invention could not have been made without the inventor's extensive efforts to achieve an appropriate Bismuth emitter.

The emitter was implemented by the aforementioned skilled Ph.D. into a time-of-flight secondary ion mass spectrometer, which needed special modification for the operation with Bismuth. Finally, the secondary ion emission for atomic primary ions and the different Bismuth cluster primary species had to be investigated by this Ph.D. to discover the benefits of the Bismuth clusters in secondary ion mass spectrometry and make the present invention.

After the invention, starting with the experimental knowledge, it took a total of about 5 more man years of this highly skilled scientist with a PhD in physics and a technician to develop Bismuth liquid metal ion sources with a reasonable emission stability and lifetime to be sold in commercial analytical instruments.

Applicants accordingly respectfully submit that the Examiner has failed to make a *prima facie* case against the independent claims.

Dependent claims

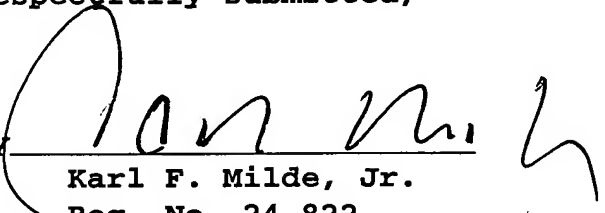
The dependent claims recite additional patentable distinctions over the references. For instance, claim 2 recites particular cluster choices, not taught or suggested by the reference.

CONCLUSION

Applicants respectfully submit that they have responded to the office action in accordance with rule 111 and submitted legally sufficient arguments for patentability - and that the application is accordingly in condition for allowance. Any points of argument not responded to are not conceded - and Applicant reserves the right to respond thereto at a later date. Allowance is therefore respectfully requested.

Respectfully submitted,

By


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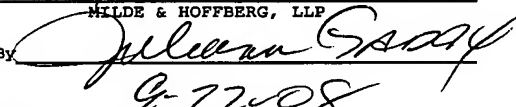
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